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Wood Energy Potential in Northwestern South Carolina

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ABSTRACT

The quantity of unused wood in an IS-county area in northwestern South Carolina was projected to be more than 16 million tons annually. Wood that is unsuitable for products other than fuel amounts to nearly 9 million tons annually. The most likely energy demand by industrial plants that are good candidates for wood fuel systems is 1.5 million tons annually. Maximum projected demand for such plants is 3 million tons per year. The area has a high potential *for development of wood energy* at *favorable costs.*

Keywords: Biomass, computer programs, forest residues, fuelwood.

Introduction

The *Energy Security Act of 1980 directed the U.S. Department of Agriculture to conduct studies on the use of wood residues for energy. In 1981, a General Accounting Office (GAO) report, "The Nation's Unused Wood Offers Vast Potential Energy and Product Benefits," recommended that the U.S. Department of Agriculture and U.S. Department of Energy conduct a series of studies to assess the energy potential of woody biomass in promising locales of the United States. In 1982, these two projects were merged to mutual benefit when Energy Security Act funds were allocated for studies in New England, the Lake States, the Northwest, and the Southeast. This Report summarizes the study conducted in the Southeast and presents the major results.*

Study Area and Objectives

The Southeast study focused on an 18-county area that covers approximately the *northwestern third of South Carolina (fig. 1). This group of counties was selected on the basis of several factors. The area is to some degree geographically discrete because it is bounded on the southwest by the Chattooga, Tugaloo, and Savannah Rivers (the Georgia State line) and on the north by the Southern Appalachian Mountains. The counties form one of the USDA Forest Service Survey Units, which ensures that certain summary data are readily available. Also, an earlier study by Harris (1982) had indicated a wood surplus in the six most northwesterly counties.*

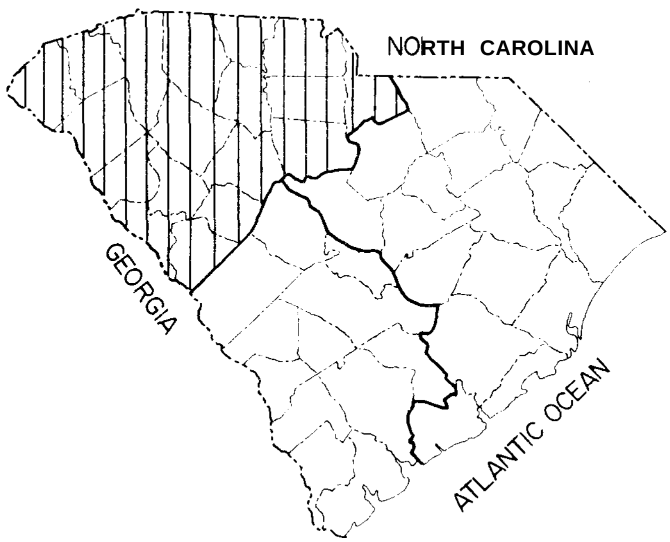

Figure 1 .-Map of South Carolina showing the 18-county study area.

The area is entirely Piedmont Plateau except for a narrow fringe at the edge of three counties that lies in the mountains along the Blue Ridge escarpment. *Out of a total of* 6,717,387 acres, 68 percent (4,566,782 acres) is forested (Snyder 1978). A little less than 1 percent of the forested land is classified as "reserved timberland," with the remainder considered timberland. In this context, "timberland" is forest land producing or capable of producing crops of industrial wood and not withdrawn from timber production. Forest industry owns only 13.2 percent of the timberland. The largest ownership categories are farmers and miscellaneous private individuals with 34.7 and 32.3 percent of the acreage, respectively. Other ownership classes are miscellaneous corporations, 10.3 percent; National Forests, 7.5 percent; other Federal, 0.9 percent; and State and local governments, 1.1 percent. The forest-type groups represented are:

Forest-type group	Percentage of timberland
Loblolly-shortleaf pine	49.4
Oak-hickory	32.5
Oak-pine	14.9
Elm-ash-cottonwood	2.8
White pine-hemlock	0.3
Longleaf-slash pine	0.1

Virtually all of the acreage has been farmed except for the wettest areas and steepest slopes; hence, the distribution of forest types has been strongly influenced by the sequence of agricultural abandonment, natural succession, and logging of the higher quality timber for wood products. The low quality of the remaining hardwoods makes a substantial proportion of them unsuitable for conventional wood products. On some of the oak-hickory and oak-pine acreage the value of the logs is less than the cost of logging, and pines would be the preferred timber species. However, the projected return on investment precludes conversion to pine due to the high cost of removing nonmerchantable material. Utilization of this material for fuel would therefore be desirable to improve overall commercial forest productivity (McMinn 1985).

The primary objectives of this study were to

- Estimate the quantity and types of residues that could be supplied for future fuel use.

- Estimate potential demand for wood fuels.

- Analyze the potential impact of wood energy development on conventional wood products.

- Assess the general feasibility of wood energy development.

Although the assessment was for a specific area, the approach and methods used were designed to be applicable to other areas, particularly to the Piedmont of the Southeast.

Quantity and Types of Residues

There are six possible sources of residues in the Piedmont: logging residue and noncommercial stands, land conversion, precommercial thinning, salvage, primary mill residues, and surplus growing stock. Precommercial thinning was judged unfeasible in the study area, hence that source was omitted from the estimates. Residues from logging and noncommercial stands, salvage, and surplus growing stock were estimated on the basis of a custom forest information retrieval and standard published statistics, both of which were generated by the Forest Inventory and Analysis Unit (FIA) of the Southeastern Forest Experiment Station. Land conversion residues were estimated from additional data provided by the FIA Unit. Primary mill residue estimates were obtained from a 1982 Commodity Drain Survey by the Cooperative Extension Service, Clemson University.

The information retrieval provided residue estimates by forest type for three six-county groups because statistically reliable estimates could not be qenerated by FIA for smaller areas.

Data for each six-county group were apportioned among the individual counties according to the ratio of forest acreage of the county to forest acreage of the group. The distribution of forest acreage in each county among major forest types or broad management groups was based on Snyder (1978). FIA estimates of recent past treatment provided an estimate of the fraction of each forest type that would contribute to residue production.

A detailed breakdown of residue type by county was derived to serve as input for the assessment of general feasibility of wood energy development, which includes production costs.

Overall estimates, in thousands of green tons per year, for the study area were:

Logging residues & noncommercial stands	*6,770*
Land conversion	*255*
Salvage	*919*
Primary mill residues	*1,020*
Surplus growing stock	*7,164*
	16,128

Two exploratory studies were conducted as well. The first dealt with use of available digitized elevation data in conjunction with satellite imagery to adjust recoverable residue estimates on the basis of slope. The intent was to deduct from estimated residue that fraction in each forest type that occurs on slopes greater than a specified operability threshold. This effort was unsuccessful because the digital terrain model used was not sensitive enough to slope, and the satellite land-cover classification failed to distinguish nonforested from forested land. Land with fence rows, orchards, residential subdivisions, etc., was frequently classified as mixed upland hardwood--the forest type of highest priority for energy use in the Piedmont.

If *a slope-related deduction from estimated residue is to be made, the best data source is still slope estimates by FIA field crews.*

The second exploratory study dealt with development of biomass prediction equations for use with 1:24,000-scale *color infrared monoscopic photo coverage. An overall equation of low reliability (coefficient of variation of 36 percent) was found to be just as reliable as equations for specific forest types in predicting total biomass. Residue estimates based on such an equation would entail applying the equation to different forest types and conditions, then using an appropriate residue fraction for each set of conditions to derive residue from total biomass.*

Potential Demand for Wood Fuels

The object was to establish a general framework by which potential regional demand for wood energy could be derived from public information. The strategy was to employ financial equations for cash-flow analysis of alternative energy systems in existing industries. The underlying rationale was that industry is by far the largest energy-consuming sector (about 65 percent of statewide use) and the financial climate is the driving force behind system conversion. Major-size firms (those with 50 or more employees and at least one boiler with a capacity in excess of 20,000 pounds of steam per hour) were targeted. More than 100 installations qualifying as major-size firms were identified in the study area from the National Emissions Data System and the South Carolina Industrial Directory. An additional constraint was that the financial analysis had to indicate a maximum payback period of 3 years. This approach identifies installations that are good conversion candidates.

The cash-flow analysis was based on the "Wood IV" system published by the N.C. Department of Commerce (1982). The model generates net cash-flow values from the engineering aspects of the system, fuel characteristics and prices, and financial variables that include Federal and State taxes and credits. Regional averages were used for boiler capital and maintenance costs.

Payback periods were derived for a range of boiler system sizes under different sets of assumptions. The critical system size for each set of assumptions was used in conjunction with regional energy consumption per employee to determine an upper limit for system size. A number of demand estimates were developed by varying assumptions over a "reasonable range" regarding interest rates, oil prices, wood prices, and higher base prices for both fuels. The aggregate estimated demand ranged from 0.6 to 3 million tons in the intermediate term, with the most likely level approaching 1.5 million tons per year.

Potential- Impact of Fuel Wood Use on Conventional Wood Products

The relationship between increased wood fuel use and the price and availability of wood for the more conventional products such as pulpwood, saw logs, veneer logs, etc., was analyzed.

The demand for conventional products was derived from the South Carolina Commodity Drain Survey conducted annually by the Cooperative Extension Service, Clemson University. Data from 1972 to 1981 were used to determine annual production for pine and hardwood products by county, and to determine conventional product mix, industrial capacity, delivered value, and unit price. Industrial capacity for each product was estimated by summing over the 18-county area the maximum annual production in each county during the 10-year period. Demand for wood fuel was from Harris (1982) and from the preceding section.

Pine pulpwood, the largest conventional product category with an average annual production of over 2.5 million green tons, is approximately double the next largest category, pine sawtimber. Hardwood sawtimber and pulpwood combined averaged nearly 1 million tons per year. Overall production averaged more than 5 million tons annually for the lo-year period, with a range from 4,212,340 to 5,636,455 tons. The derived maximum capacity is approximately 6 percent greater than the highest single-year production, which occurred in 1976. Estimated postharvest residue ranges from 3.2 to 4.3 million tons annually. Based on product output, for 1981 the estimated acres harvested was 176,000, which is fairly consistent with the estimated 189,000 annual acreage derived from FIA data for this category of residues. Since the potential demand ranged from about 0.6 to 3 million green tons annually, this residue source alone could theoretically satisfy demand.

A number of industrial plants considering new solid-fuel combustion systems have found the cost of wood approximately equal to the cost of coal, so the ceiling price possible for wood fuel may depend on the price of coal rather than oil and natural gas. Recent (1982) delivered wood fuel prices range from about $14 to $18 per green ton. This approximates the delivered price for hardwood pulpwood, which is the only conventional product that wood fuel approaches in price. Greater fuelwood demand than anticipated in this study is judged to pose no problem for pulpwood supply, and the probable effect on the saw-log market is a simultaneous lowering of costs and higher quality logs. The rationale for this expectation is that more acreage would be harvested and, because of their value, saw logs existing on this acreage would be marketed separately by the producer rather than included in the fuel mix.

Feasibility of Wood Energy Development

A common perception among managers, who might consider wood energy an option, is that it is uneconomical to transport residues more than a very short distance. A 20- to 30-mile maximum is frequently assumed. A recent study of mill residues in Georgia (Eza and others 1984a) showed that, from a practical standpoint, transportation is not a limiting factor. To assess the general feasibility of wood fuel development, their supply-demand allocation model called Wood Residue Distribution Simulator (WORDS) was used (Eza and others 1984b).

As a measure of supply attractiveness, WORDS used purchase and delivery costs which include the cost of recovering residues and of transporting them to the demand location. WORDS systematically allocates supply to demand such that a least-cost overall allocation is approximated. The current version allocates until either all supply is exhausted or all demand is satisfied, but it prevents allocation of any supply with a higher cost than some specified alternate energy source. The total cost of acquiring and shipping wood fuel from each supply location to each demand location is also calculated. WORDS requires-three basic inputs: quantity and cost of each type or combination of residues at each supply location, transportation costs specified as some function of distances between supply and demand units, and alternate energy costs at each demand location. For each source of demand, supply locations are divided into up to nine preference categories according to the delivered costs of supply. The user specifies the cost boundaries on each preference class. The model will handle several categories of material at each of 160 potential supply and demand locations.

To evaluate the model for this application, supply and demand values were taken from our estimates of quantity and type of residues and potential demand. Four types of residues were considered in this analysis--surplus growing stock was not used. The types, quantities, and their estimated average costs at the supply locations were:

Type A: residues recovered by integrating existing roundwood operations to harvest tops, branches, and small trees; 6.77 million tons; $27/ton.

Type B: residues recovered from noncommercial forest-land conversion; 0.255 million tons; $18/ton.

Type C: forest-land salvage operations; 0.919 million tons; $18/ton.

Type D: primary mill residues; 1.02 million tons; $12/ton.

Wood energy values were derived from published information and transportation costs from published information and a survey of wood products transporters in Georgia. Twelve scenarios were developed, and eight were used to evaluate general wood energy feasibility in the study area. Table 1 summarizes the assumptions used in each scenario. An

Table 1.--Scenarios used for WORDS simulator to evaluate wood energy feasibility in northwestern South Carolina

Scenario	Residue type[a]	Alternate energy cost	Wood prices
		$\$/10^6$Btu	
1	D	6.25	base
2	C	6.25	base
3	D	6.25	base
4	C,D	6.25	base
5	B,C,D	6.25	base
6	A,B,C,D	6.25	base
7	C,D	9.38	base
8	C,D	6.25	base
9[b]	C,D	6.25	1.5 base
10[c]	C,D	6.25	base
11[d]	C,D	6.25	base
12[e]	C,D	6.25	base

[a] A = logying residue, B = land conversion, C = salvage, D = mill residue.

[b] First allocate C, then allocate D.

[c] Use $2 rather than $5 preference class.

[d] Add simulated power plant (410,000 tons/year).

[e] Use linear programming.

alternate energy price of $6.25 per million Btu's is the equivalent of natural gas at $5 per thousand cubic feet and 80 percent efficiency.

The first three scenarios allocated all of the respective supplies at favorable cost (table 2), but none fully satisfied the overall demand of 1.5 million tons. The fourth scenario used the two least expensive residue types, which together would satisfy total demand; this scenario indicates that even at an upper boundary for demand estimates, wood energy could be supplied at a significantly lower cost than natural gas energy. Scenarios five and six added successively more expensive residues to the allocation pool. Scenario seven used a natural gas price of $7.50 per thousand cubic feet, and scenario eight added 50 percent to wood residue purchase price with transportation cost the same.

The last four scenarios were intended only to evaluate WORDS as a tool for this type of general assessment, since preceding scenarios had already given strong indication of wood energy potential in the study area. Note that the last scenario used a linear programming formulation to find the absolute least-cost overall allocation, but it is much more expensive than the simulation approach. Simulation expense and accuracy are both affected (in opposite directions) by the specified width of preference classes.

WORDS can be used without modification to evaluate supply-demand networks in other geographic regions. The model currently permits up to 160 demand locations, 160 supply locations, and eight types of material, which may be allocated singly or in any user-specified combination. This particular assessment agyregated both supply and demand to the

Table 2.--Summary of simulation assessment of wood energy feasibility showing those counties with minimum and maximum costs for each scenario, northwestern South Carolina

Scenario	Minimum County	Minimum cost	Maximum County	Maximum cost	Average cost
		$\$/10^6$Btu		$\$/10^6$Btu	$\$/10^6$Btu
1	Oconee/York	$2.63	Lancaster	$3.34	$2.91
2	Edgefield	3.92	Greenwood	4.17	4.07
3	Edgefield	3.91	Cherokee	4.17	4.06
4	Saluda	3.06	Spartanburg	3.60	3.38
5	Greenwood	3.06	Spartanburg	3.64	3.41
6	Newberry	3.87	Anderson	5.03	4.51
7	Saluda	3.06	Spartanburg	3.60	3.38
8	Newberry	3.96	Greenville	5.19	4.59
9	Oconee	2.63	Spartanburg	3.88	3.30
10	Newberry	2.80	Cherokee	3.67	3.25
11	Saluda	3.06	Power plant"	3.75	3.48
12	Newberry	2.80	Lancaster	3.69	3.19

[a] Scenario 11 *simulated the addition of one more demand source, a hypothetical power plant requiring 410,000 tons of residue annually: this quantity was equal to the excess of supply over demand when mill residues and salvage residues were allocated. The location of the plant was the approximate geographical center of the study area, Laurens County. This simulation resulted in the average cost of supply for the power plant itself being the highest of all demand sources.*

county level, but the level of aggregation is up to the user. The physical size and number of supply units and demand units need not be the same, and the user can subdivide a system in any way as long as supply units do not overlap and demand units do not overlap.

Discussion

This analysis indicates that there is a high potential for using wood as an energy source in northwestern South Carolina. If fuel production were confined to the material not suitable for other forest products, the supply could easily accommodate all industrial plants that are good candidates for conversion, plus a small power plant (about 50 megawatts). If material is included that is suitable for other forest products, but not projected to be used, the potential supply is 16.1 million tons per year--over 10 times the projected demand of 1.5 million tons annually by industrial plants that would be good candidates for conversion. These estimates are all at costs that compare favorably to the cost of currently used energy sources. These results raise a question about the lack of substantial wood energy development in the study area.

Although there are regional differences, GAO has determined that several barriers appear to have a significant effect on residue use nationwide:

1. *Inadequate data on the volume, location, accessibility, and availability of forest residues.*

2. *Lack of economical and effective equipment for harvesting and transporting residues.*

3. *Lack of investment capital needed for harvesting and using residues.*

4. *Limited awareness and acceptance of wood energy and product technology among industrial firms, utilities, and State and local bodies.*

Additional obstacles were judged by GAO to discourage or prevent residue use in some areas of the country:

5. *Federal forest management policies and programs.*

6. *Utility practices and regulations.*

7. *Environmental concerns related to greater use of residues.*

The Southeast study did not address the question of barriers explicitly. However, based on 8 years of wood-energy related work in the region, my impressions are as follows. Of the seven items listed, only items 4 and 6 have a significant influence on residue use in the study area. Lack of awareness and acceptance have been and remain a barrier. My perception is reinforced by the greater degree of wood energy use in neighboring Georgia and North Carolina, both of which have had aggressive wood energy promotion programs since 1978. In addition, as of 1982 South Carolina derived 36 percent of its electrical energy from nuclear reactors, which are concentrated in the study area. Had the nuclear commitment not been made before the OPEC scare of the early 1970's, wood might have been considered more seriously either as an electrical power source or, certainly, as an industrial energy source.

Information on wood raw material in the Southeast is probably as good as in any other region, if not better. However, from my observations, potential users will require more precise, location-specific data to gain confidence about the use of this unfamiliar raw material. Remote sensing may provide a partial solution. The remote-sensing applications attempted in this study focused on readily available and inexpensive data, but were too "quick and dirty" to provide estimates any more refined than the data available from standard FIA surveys. These tests by no means eliminated remote sensing as a potential tool for estimating fuelwood supply.

The quantitative tool used in assessing general feasibility (WORDS) should provide a good general framework for this type of study in other areas. If the analyst begins with WORDS as the framework, a substantial proportion of the relevant data will be collected as input.

Conclusions

• Current residue types, volumes, and roadside costs in the study area are:

Residue type	10^6 green tons	Dollars per ton
Logging residues & noncommercial stands	6.770	27
Land conversion	0.255	18
Salvage	0.919	18
Primary mill residues	1.020	12

• Potential demand estimates ranged from 0.6 to 3 million tons in the intermediate term, with the most likely level approaching 1.5 million tons per year.

• Wood fuel development is judged to have little effect on other industrial wood except, perhaps, for a simultaneous decrease in price and increase in quality of saw logs.

• The primary barrier to wood energy development is judged to be a limited awareness and acceptance among industrial firms, utilities, and State and local bodies.

• Wood residue energy development should be generally feasible in the area and, in fact, would support a small power plant (50-megawatt range) at favorable prices.

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KEYWORUS Biomass, computer programs, forest residues, fuelwood.

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